kept clean locally. They are living structures, and their power of resistance varies with the general health, and this, like the health of the teeth, mainly depends on a supply of natural foods in proper quantity, especially in early life when tooth-formation occurs. Early life means especially embryonic life, and the proper feeding of expectant mothers is a *sine qua non*. Sophisticated and patent foods are specially harmful, for they, as a rule, lack the necessary "vitamins," which were then described in outline. Bad teeth in their turn undermine the general health, and, by forming foci of infection, lead to general ill-health, indigestion, blood-poisoning, rheumatoid affections, and the like, and so a vicious circle is produced, the abolition of which becomes a national duty.

After a general account of what is called "calcium metabolism," a series of lantern-slides was shown to illustrate not only the structure of the various parts of a tooth, but also the stages in their development, in which the cells responsible for the elaboration of the enamel prisms and the layers of dentine with its tubules and the nerves, etc., within them were seen. Occasion was taken to press home again the possibilities of injury and the necessity for care, especially in early stages and in early life, the word "early" including fœtal life. In conclusion, the lecturer looked forward to a time in the not far distant future when the teeth of the nation might be its pride, and not a source of lamentation and pain.

The Brown Bast Disease of the Para Rubber-tree.[1]

By DR. S. E. CHANDLER.

DURING the early years of rubber planting in the East considerable optimism prevailed in certain quarters as to the powers of the Para rubber-tree (*Hevea brasiliensis*) to resist disease in its new home. The planting of such great areas with a single crop plant, however, was practically certain to result sooner or later in fungal disease, to say nothing of insect attack; and, although little was (and still is) known as to the functions of latex in plants, it was safe to predict that the regular withdrawal of considerable quantities of latex from the trees would result in physiological disturbances which might become a factor of commercial importance. Events have proved these views to be well founded. As compared with many crops, rubber has been comparatively free from visitations, but several fungal diseases are now recognised and insect pests are not unknown; while a disease hitherto ascribed to physiological causes, and known as "brown bast," has attained such importance as to constitute the most dangerous cultural menace to the rubber-planting industry at the present day.

Brown bast is a disease of the bark[2] of tapped trees, but it does not involve the death of the tree, or even of the affected bark. The disease may be recognised by a difficulty in obtaining latex on tapping to the usual depth, followed ultimately by the cessation of latex flow (when the tree is said to be "dry"), and is further characterised by a brownish or olive-green discoloration of the middle and inner bark, which may show a definite brown line on the tapping cut near the cambium. External signs of the disease may be lacking, but in the more severe cases the outer bark often scales and splits longitudinally and an exudation of latex occurs. This condition sometimes results from the secondary development of woody "burrs," nodules, or plates within the diseased tissue, and, unless the case is dealt with, these bodies may cause the bark ultimately to become so knotted and irregular as to be useless for tapping purposes. The formation of burrs and nodules, however, is not necessarily associated with brown bast, as has been shown by Bateson, Bryce, and others.

Brown bast was widely reported as an epidemic in the plantations during 1916–18, and a satisfactory method of treatment became a matter of prime importance. Pending exact knowledge as to the cause of the disease, the methods recommended were based on the observations that affected latex-vessels do not again function, that the diseased portion of the bark is useless for further tapping, and that the disease "spreads" in the bark. Planters were therefore advised to remove the diseased tissue, either by "scraping" the brown bast tissue from the bark, or by carefully "stripping" off the bark down to the cambium. In the latter case, especially, measures should be taken to protect the delicate exposed surface so that a satisfactory regeneration of the bark by the cambium may take place. The removal of the superficial layers of the affected bark, followed by the application of warm tar to the exposed surface, has also been practised.

It was early recognised, however, that the best chance of devising adequate measures of control would result from a correct understanding of the nature of the disease, and considerable research on this subject has been carried out by British and Dutch botanists in the East. So far, attempts to associate the disease definitely with bacterial or fungal attack have failed, and at the present time brown bast cannot be ascribed to any causal organism, though it has been claimed by Keuchenius that bacteria are present in the diseased tissue. With the bulk of evidence against a parasitic origin of the disease, most investigators have fallen back on the theory that brown bast is a physiological disease, the result of metabolic disturbances as to the nature of which, however, little or no information is available.

Recently a series of important publications on the etiology of brown bast have appeared almost simultaneously. The results obtained are of exceptional interest, inasmuch as the work has been carried out by investigators widely separated and working independently on material derived from several different planting countries. Rands (1) and (2) has dealt with the disease in Java and Sumatra; Sanderson and Sutcliffe (3) in British Malaya; Gandrup (4) in Java; while Farmer and Horne (5) and (6), in London, have examined diseased material from British North Borneo and Malaya. These investigations throw much light on the anatomy of the diseased tissue and the probable immediate cause of brown bast, while in the case last mentioned it seems probable that a valuable advance has been made towards a correct understanding of the nature of the disease.

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[1] (1) "Brown Bast Disease of Plantation Rubber, its Cause and Prevention." By R. D. Rands. Mededeelingen van het Instituut voor Plantenziekten, Departement van Landbouw, Nijverheid en Handel, No. 47 (1921); overgedrukt uit her Archief voor de Rubbercultuur, Jaargang V., No. 5 (Mei 1921).

(2) "Histological Studies on the Brown Bast Disease of Plantation Rubber." By R. D. Rands. Mededeelingen van het Instituut voor Plantenziekten, Departement van Landbouw, Nijverheid en Handel, No. 49 (1921).

(3) "Brown Bast: An Investigation into its Causes and Methods of Treatment." By A. R. Sanderson and H. Sutcliffe. Pp. 71+26 plates. (London: The Rubber Growers' Association, Inc., n.d.) 7*s*. 6*d*. net.

(4) "Over den Steencellenring in de Schors van Hevea." Door Johannes Gandrup. Mededeelingen van het Besoekisch Proefstation, Rubberserie, No. 19 (1921); overgedrukt uit het Archief voor de Rubbercultuur, Jaargang V., No. 9 (September, 1921).

(5) "On Brown Bast and its Immediate Cause." By J. B. Farmer and A. S. Horne. *India-Rubber Journal*, vol. 61, No. 25, June 18, 1921.

(6) "Phloem Necrosis (Brown Bast Disease) in *Hevea brasiliensis*." By Arthur S. Horne. *Annals of Botany*, vol. 35, No. 139, July 1921.

[2] The term "bark" is here used in the planter's sense of the tissue actually involved in the tapping operation.

The two papers of Rands (1) and (2), who published preliminary reports in 1919 and 1920, are complementary. The first-mentioned paper contains a full statement to date of the results of the author's investigations commenced in 1918 at the instance of the Director of the Government Rubber Estates in the Dutch East Indies, and still in progress. Rands's results support the view of the non-parasitic origin of the disease, and indicate that the repeated withdrawal of the latex from the same tissues is the chief causal factor concerned. The drained tissues respond by secreting a gum, which in its effects prevents a further loss of latex. The time-interval between successive tappings and the system of tapping adopted appear to be the most important predisposing factors; in the author's experience a heavy occurrence of the disease is invariably associated with a drastic system of tapping. The second paper records the botanical (anatomical) evidence on which the results are based. According to Rands, brown bast appears to be a special type of wound-gum secretion favoured by conditions which promote the vital activity of the tree. The characteristic brown discoloration of the diseased bark is stated to be due to the deposition of a yellow plastic " gum " in the cavities of the latex-vessels and in many of the intercellular spaces of the bark (phloem) parenchyma, thus recalling similar observations made by Bobilioff.

The gum is formed, not by the breaking down of cell-walls, but as a secretion of the protoplasts of the parenchymatous cells adjacent to the latex-vessels. It passes into the latter through the common cell-wall (which is thereby stained yellow), and also into the existing intercellular spaces or into such spaces formed and enlarged under the stimulus of the secretion. It is secreted in largest quantities during the wet season, and is most abundant in vigorous trees in full growth. Investigation showed that the gum is practically identical with the " wound-gum " formed locally as a result of artificial wounds made in the wood and bark of the tree, and is similar to the corresponding product in other plants. It differs from the true gums, however, in its chemical reactions. The clogging of the latex-vessels appears to be the chief factor in arresting the latex flow, but the coagulation of the latex within the vessels is also indicated as a contributory factor. Under the highest powers the gum is seen to possess a well-marked alveolar structure which is not an artefact. Rands was unable to determine whether the gum-formation results from enzyme action, as has been suggested in the case of the gummosis of Prunus. As regards the burrs, Rands's results in general confirm the previous work of Rutgers, Bateson, Bryce, and others, and especially the suggestion of Bateson that burr-formation is favoured by excessive tapping. The woody burrs arise from the activity of a secondary cambium formed about a group of gummed latex-vessels; the varied form of the mature structure (pea-shaped, knobby, or plate-like) depends upon the disposition and extent of the secondary cambium.

The book by Sanderson and Sutcliffe (3) is primarily intended as a practical guide for estate managers in diagnosing the disease and in treating affected trees. The authors lay special emphasis upon the desirability of early treatment, and recommend " stripping " of the bark, not only as curative in effect, but also as the simplest and cheapest procedure. A considerable portion of the book, however, is devoted to the results of a microscopical study of the disease, and the authors claim their work to be the first attempt to describe the pathological anatomy of brown bast and to formulate a theory by which the observed facts may be explained. They regard brown bast as physiological in origin, and consider tapping to be its prime cause. As regards pathological anatomy, Sanderson and Sutcliffe find that the constant and characteristic feature is a meristematic activity of the parenchyma cells of the bark. Other characters described by them, viz. the deposition of " tannins " and crystals of calcium oxalate, the occurrence of abnormal numbers of stone-cells at unusual depths in the bark, the depletion of starch, and the presence of globules of " oil or fatty matter " (suggested possibly as a substitution product for starch, or as the result of a breaking down of that substance), are regarded as secondary symptoms arising from the meristematic activity.

Elsewhere, however, the authors state that the occurrence of " tannins " is not characteristic of the disease, while large numbers of oily globules are not constantly present. The meristematic tissue originates at a point roughly corresponding to the depth of tapping, and occurs almost invariably in the immediate vicinity of the latex-vessels. The result is a partial displacement of these vessels, which, in consequence, are often ruptured, the latex percolating into the intercellular spaces, where it coagulates. The latex within the vessels also appears to be coagulated *in situ* (*cf.* Rands), possibly through the agency of the by-products of the metabolism of the actively dividing cells. The coagulated latex is considered to be an additional source of irritation, stimulating the surrounding tissue to further meristematic activity.

The views put forward by these authors as to the immediate origin of the disease are interesting. They consider that the abnormal meristem may be due to the stimulus arising from the wound meristem formed just beneath the surface of the tapping cut, or it may be a secondary effect of the abnormal vigour of the cork cambium which early arises over the previously tapped surface to form the renewal bark. Sanderson and Sutcliffe regard it as " highly probable " that the growth of this cork cambium " provides the stimulus for starting meristematic activity at an equal, or almost equal, depth in the cortex below the tapping cut, *i.e.* in the untapped portion of the cortex below." Such induced cambial activity spreading from the renewal bark was first described by Lock, but it is not quite clear from the present paper whether Sanderson and Sutcliffe have independent evidence of a similar phenomenon in the case of brown bast.

As regards burr-formation, the case is put that, while the meristem of brown bast may remain as such, it may also give rise to woody tissue internally and unlignified elements externally. It is in this latter manner that burrs originate, and the degree and character of the burr-formation depend upon the amount and disposition of the meristem concerned. Sanderson and Sutcliffe ascribe considerable importance to the production of stone-cell tissue as a secondary character of brown bast. In this respect they are supported by other writers. The cells on the outer limits of the meristem may be largely converted into stone-cells, which sometimes form extensive scleritic masses resulting in the scaling of the outer bark. The observations of Gandrup (4) are interesting in this connection, since this worker shows that in the young Hevea plant the stone-cells arise among the thickened prosenchymatous pericycle fibres (bast fibres), which later are almost completely replaced by a ring of stone-cells.

The papers of Farmer and Horne (5) and (6) give the results of a research carried out in the botanical laboratories of the Imperial College of Science and

Technology on material received from British North Borneo and Malaya. The work formed the subject of an exhibit at the Rubber Exhibition of 1921, and was briefly noticed in NATURE of June 16 last, p. 499. It is understood that further work is in progress, and that a full illustrated account of the results will be published. These authors have concentrated attention upon the earliest stages of the disease, and obtained results which definitely advance the problem a step towards solution. In transverse sections of diseased bark, numerous minute golden-yellow spots of irregular outline were observed in the phloem from the cambium outwards. Under high magnification these coloured areas sometimes appeared to resemble intercellular spaces (*cf.* Rands's work), but on careful examination the golden areas were found to be sections of necrotic *sieve-tubes*, the waved outlines in many cases being clearly transverse sections of the large vertical sieve-plates characteristic of Hevea phloem. In the young phloem the disease is confined to the sieve-tubes, but in the older tissue phloem parenchyma, medullary-ray cells and latex-vessels have been involved in the local tissue degeneration. Commonly, a diseased area was found to be more or less completely surrounded by an active meristem (" wound-cambium "), which in some cases gave rise to lignified elements and constituted the initial stages of a burr.

It will be seen that this investigation emphasises the fact that, quite apart from the latex-vessels, elements (sieve-tubes) of vital importance in the nutritional processes of the plant are injured during tapping. The sieve-tubes cease to function and, in becoming disorganised, initiate the condition known as brown bast. The disease, therefore, is primarily due to phloem necrosis analogous to the cases of similar disease reported in the potato and in Liberian coffee. Observations were also made regarding the origin of burr development. It is stated that, as a result of the activities of the wound cambiums, diseased groups of cells become enclosed in " pockets " of stone-cells. Sanderson and Sutcliffe also refer to stone-cells derived from the pathological meristem in the bark tissue.

In reading this series of papers for the first time it is difficult to believe that the authors are dealing with the same problem. No evidence for a parasitic origin of the disease is brought forward in any case, but their respective investigations lead the authors to differ in their views as to the immediate origin of the disease. Sanderson and Sutcliffe point to an induced meristematic activity in the bark as the characteristic feature of the pathological anatomy. To Rands the disease is a special case of gummosis which is the outcome of a wound response resulting from tapping; while Farmer and Horne regard phloem necrosis as, " beyond doubt," the immediate cause of the disease. The present writer carefully examined Horne's remarkable preparations and camera-lucida drawings shown at the Rubber Exhibition last year, and recently he has been allowed to compare further the drawings with the illustrations accompanying the papers of Rands and of Sanderson and Sutcliffe. He considers that the true relations of the seemingly conflicting results are apparent on the view that a difficult piece of anatomy has been carried out to varying degrees of finality by the respective workers. In the case of Horne's work there is little doubt that his investigation has shown that the immediate cause of brown bast is a degeneration of the sieve-tubes and neighbouring elements, accompanied by the more or less complete localisation of the necrotic area by an active meristem. Rands's research appears to have fallen just short of complete success. In spite of his histological methods to prove his " intercellulars " to be such, comparison of his drawings with those of Horne strongly suggests that they are the necrotic sieve-tube areas illustrated by the latter worker. It is remarkable that throughout Rands's anatomical paper he uses the word " sieve-tube " twice only, though in the only diagram in which sieve-tubes appear each of the two sieve-tubes figured is blocked with " gum." Rands's view that the disease is a type of " gummosis " is by no means beside the mark; it may well be so regarded in its ultimate symptoms, but he failed to detect the primary cause. The abundant meristematic activity emphasised by Sanderson and Sutcliffe would appear to be a secondary character, and is possibly a development of the pathological meristem referred to by Farmer and Horne. It may be significant in this connection that the bark examined by Sanderson and Sutcliffe was from trees which " had been taken out of tapping for some little time owing to brown bast," and in which, therefore, there may have been time for the meristem to reach considerable development. The suggestion that the pathological meristem is formed as a result of the stimulus afforded by the activity of the cork-cambium of the tapped bark above the diseased area is interesting, and the authors might usefully have given further evidence in support of the contention.

There would appear to be some difference of opinion as to the condition of the starch reserves in the diseased bark. Sanderson and Sutcliffe report that starch is usually absent, or present in small quantities only, and regard this depletion as accounted for by the demands for food materials made upon the neighbouring tissue by the meristematic cells. Rands, however, states that evidence based on observations of the starch reserves indicates that the response of the tissues, resulting in the " disease," is more the effect of a stimulus connected with a loss of latex than of an actual depletion of (starch) reserve food, though he suggests the possibility of effects caused by the temporary depletion of other food substances, *e.g.* the proteid constituents of the latex which are known to suffer a reduction as the consequence of hard tapping.

If the initial occurrence of phloem necrosis is confirmed, there will remain the problem of the cause of this condition. The solution of the problem is inseparably connected with the general question of phloem necrosis in plants. Thus light may be thrown on brown bast by the recent work of Quanjer, who claims that phloem necrosis in the potato can be transmitted from one plant to another.

As pointed out by Farmer and Horne, the current investigation of brown bast disease points clearly to the urgent need for a wider understanding of the general physiology of Hevea, in which, of course, the laticiferous system would call for special attention. The present writer ventures to suggest that before this question (of which little is as yet known) can be dealt with successfully, it is essential that fuller knowledge of the anatomy and histology of laticiferous tissue in general should be available. Useful pioneer work has been done by Meunier, but the papers under review show how far from complete such knowledge is at present in the case of Hevea alone. There is little doubt that, as in zoology, *comparative* anatomy would be highly suggestive and helpful. The study should extend at least to carefully selected arboreal laticiferous plants, of which the various " rubber-trees " which have been cultivated or exploited commercially would probably be sufficient, since the character of their laticiferous systems varies greatly in important features. The essential difference between the laticiferous systems of Hevea and Funtumia, and the presence in Castilloa, Funtumia, and Landolphia of a striking development of laticiferous tissue in the xylem (medullary rays), connecting the latex-tubes in the phloem radially with those in the pith, are but instances of a significant state of affairs. A thorough study of this question could not fail to lead to important scientific knowledge which, in competent hands, might well result in practical applications. Again, such striking facts as the occurrence in *Funtumia elastica* of an excellent latex rich in caoutchouc, while in the closely related *F. latifolia* (often found growing with the former species) there is a commercially useless latex containing abundant "resins" in place of caoutchouc, present problems, difficult indeed, that might well receive more attention at the hands of biological chemists. The preliminary anatomical work would be best carried out in the tropics, but with a little organisation much might be accomplished in this country, as is evident from the fact that observations which may prove to be the key to the correct understanding of a baffling disease of Hevea have recently been made in London.

See also 1923 Vol. 17 p 234

Dairy Cattle and Milk Production.

THE urgency of the problem of milk supply has of late years caused much attention to be devoted to the improvement of dairy cattle, and to the increase of milk supply on an economic basis. During the last twenty-five years the Danish Milk Recording Societies (*Journ. Min. Agric.*, October and November 1921) have been working towards the improvement of herds by the gradual elimination of unproductive cows, and Government grants have been made to aid them in the formation of strains of dairy cattle producing a higher yield of butter. The keeping of private and official handbooks is encouraged, and a special feature is made of two-year competitions between entire herds, the best herds being awarded prizes and officially recognised as breeding centres. The earlier work dealt entirely with the yield of cows, but later it was realised that the character of the bull was of equal importance with regard to milk production, as high milk-yielding capacity is a character that can be inherited through the sire as well as the dam. By close observation of records and careful breeding, attempts have been made to obtain bulls with a good influence on the milk yield, with considerable success. As Denmark is chiefly a butter-producing country, the main object of the milk-recording societies has been to raise the percentage of butter fat, thus aiming at improvement of quality more than at increase of quantity.

The milk problem is by no means confined to European countries, but various aspects of dairying are being investigated elsewhere, as in the Madras Agricultural College, India (Bull. No. 79). Special consideration is given to business aspects as well as to the technical methods of dairying. Approved methods of selection are applied to the dairy herd, unprofitable cows being weeded out, and pedigree registers are maintained. A creamery is also run for the preparation of butter on a commercial scale, milk being purchased from outside to supplement the home supply. The prospects of success are good, and a future seems to be before the dairy industry of India if it is managed with scientific and business knowledge.

One point which has a close bearing on dairy-farming is the varying cost of milk production, which has ranged from 3¼*d.* to 4*s.* 7½*d.* per gallon since 1908 on Yorkshire farms for which records are available (*Scottish Journ. Agric.*, vol. 4, No. 4). Some of the factors concerned are not under the control of the producer, and are due to increase in the labour and food bills, and to the increased depreciation of the cows. In pre-war time the cost of attention per cow per week varied from 1*s.* 6*d.* to 2*s.*, but owing to the rise in agricultural wages it is now 4*s.* 6*d.* to 6*s.*, an increase which is estimated to have added 4*d.* per gallon to the pre-war cost of milk production. The cost of food has risen on every hand. Grazing is far more expensive owing to increased cost of manure and upkeep, home-grown food costs at least twice as much to produce, and, above all, purchased food has risen so much in price that it is probably the one factor more than any other which has been responsible for the high prices of milk during recent years. During the war, too, the difference in value between in-milk and dry cows greatly increased, and this depreciation in value has had its effect upon the cost of milk production. The tables drawn up indicate that in some cases the total costs have exceeded pre-war costs by 300 per cent., but happily there are indications that the inflated prices are easing off, and they show signs of being still lower in the near future.

W. E. B.

University and Educational Intelligence.

CAMBRIDGE.—The Smith's prizes have been awarded to E. A. Milne, Trinity College, for an essay on "Studies in the Theory of Radiative Equilibrium," and to G. C. Steward, Gonville and Caius College, for an essay on "The Aberration-Diffraction Problem." A Rayleigh Prize has been awarded to T. A. Brown, Trinity College, for an essay "On a Class of Factorial Series."

J. A. Carroll, Sidney Sussex College, has been elected to an Isaac Newton Studentship, and the Studentship of W. M. H. Greaves, St. John's College, has been renewed for a year.

Regulations have been proposed for the degrees of M.Litt. and M.Sc. The chief difference from the Ph.D. regulations are that a student must for these degrees do research for two years as against three for the Ph.D. The Board of Research Studies publishes its second annual report. There have now been 143 research students admitted, of whom 5 have already taken the degree of Ph.D. Of these 95 are working in scientific subjects—physics with 22, chemistry with 16, and botany with 12, head the list.

LONDON.—The under-mentioned French professors in the Faculty of Medicine of the University of Paris will lecture (in French) at the Rooms of the Royal Society of Medicine, 1 Wimpole Street, W.1, at 5 P.M., on the dates stated:—

March 20, Prof. H. Roger (Dean of the Faculty), "Les fonctions du Poumon"; March 23, Prof. A. Chauffard, "Syndrome Humoral de la Goutte"; March 27, Prof. P. Duval, "Données actuelles de la Chirurgie Intra-Thoracique."

PROF. H. R. DEAN has been appointed as from June 1 next to the University Chair of Bacteriology tenable at University College Hospital Medical School. Since 1915 Prof. Dean has been Professor of Pathology and Pathological Anatomy in the University of Manchester. He has been Horace Dobell Lecturer for the Royal College of Physicians, and is the author of numerous papers on pathological and bacteriological subjects.